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DEATH BY LIVER CIRRHOSIS AND THE PRICE OF BEVERAGE ALCOHOL*

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ANY CONDITION that causes death may well be of interest to physicians, no matter how relatively rare the prevalence. More particularly might they be interested if, simultaneously, prevalence were rising while measures, perhaps quite simple, to reduce these death rates appeared to be available. If, in addition, the measures suggested did not add to the workload of the already overburdened physician, they might well be as welcome as mosquito abatement in relation to yellow fever.

Liver cirrhosis as a cause of death may well be in this category. Its contribution to mortality is small, though not exactly trivial, in modern Western nations. In Canada, in the last 50 or 60 years we have seen rates[1] as low as 5.2 per 100,000 adults and as high as 11.4. Deaths so attributed have also ranged from about one-quarter of one per cent to about two-thirds of one per cent of all mortality.[1] Such mortality is roughly comparable with suicide, or leukemia.

If we restrict interest to the years 1921-56 for which the data are relatively reliable, we get an impression of a rather dramatic rise in the proportion of the general mortality attributed to liver cirrhosis—and this at a time when nutritional deficiencies (which are commonly thought to be a contributing cause) have been widely and steadily diminishing. The average annual increase in the relative rate has been about 4% of each preceding year's rate, and the trend is so steady that statistically it "accounts for" 92% of the variance in mortality,[2] as Fig. 1 shows. Moreover, the picture is similar no matter whether we take all of Canada as the reporting unit, or Ontario alone, or even so small an area as Toronto.[3]

Nor is this increase to be attributed in any important way to changes in the age-sex composition of the population. If the raw data are recomputed as age-sex specific mortality rates, and the then "expected" mortality is referred to a "standard million" of population, a linear fit of the data to time still accounts for 86% of all the variation found. In other words, only about 6% is attributable to age-sex changes[4] in the population.

A visual impression may be gained from Fig. 2.

For a variety of reasons our interest in deaths from liver cirrhosis was led in the following directions.

RATIONALE OF STUDY

Some forms of liver cirrhosis, and more particularly some cirrhosis of sufficient severity to be a cause of death, has long been widely spoken of as a "complication of alcoholism".[5] Indeed so close has the relation been held to be that liver cirrhosis death rates have provided the basis upon which nearly all alcoholism prevalence rates have been estimated[6 a, b] even though it is not known what proportion, within very wide limits, of such deaths are due to or associated with alcoholism.[7 a, b, c]
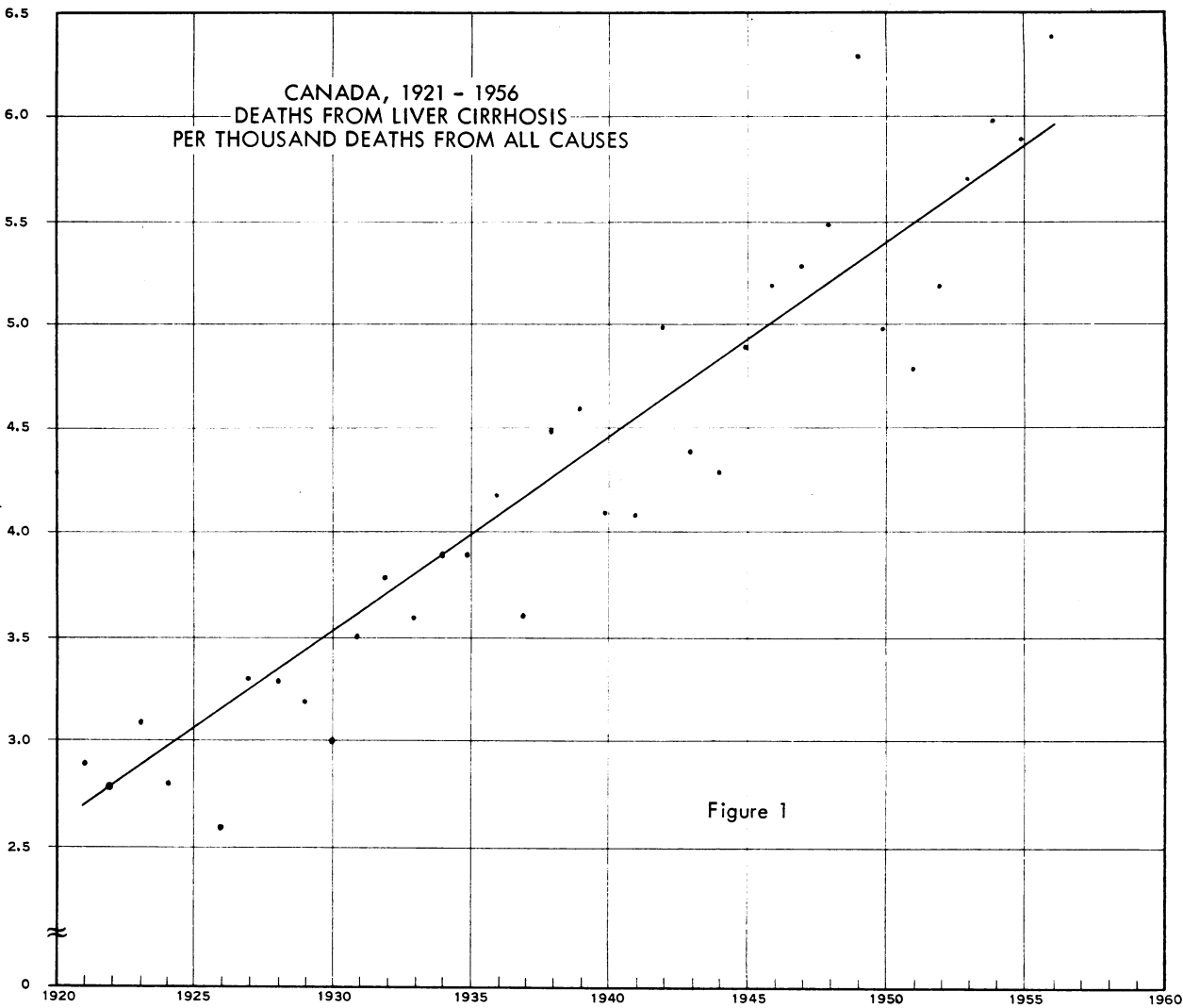
Given the fact, however, of a strong association between liver cirrhosis deaths and "alcoholism prevalence", we might well ask how close the association is between the death rate from cirrhosis and the consumption of beverage alcohol.

If, moreover, that association should prove to be close and positive, then an interest in economics or public health will prompt us to enquire further as to the dependence of alcohol consumption on the price of alcohol. It is into these two aspects that this paper is, more narrowly, to enquire.

Data.—Readily available[1] for Ontario and Canada are (a) liver cirrhosis death rates, (b) dollar sales values of licit alcoholic beverages purchased, (c) gallonage by type of beverage (beer, wine, distilled spirits), (d) population 20 years of age and over, and (e) disposable personal income (total personal income less taxes), and (f) consumer price indexes, if desired.

Price.—From (b), (c) and (f) we may compute the average price each year of a gallon of absolute alcohol in standard dollars. From (d), (e) and (f) we may similarly compute disposable personal income per adult in standard dollars. And from these two, we may compute the price of an average gallon of absolute alcohol as a fraction of an

CANADA, 1921 - 1956
DEATHS FROM LIVER CIRRHOSIS
PER THOUSAND DEATHS FROM ALL CAUSES

Figure 1

Fig. 1

average disposable income per adult. This "relative price" is what we shall use in what follows.

Consumption.—From (c) and (d) we may compute the consumption of absolute alcohol per "adult" (person 20 years or more of age).

Mortality.—We have the deaths from liver cirrhosis per 100,000 adults from (a).

These three sets of variables for Canada and Ontario, for the years for which data are available, respectively, are set out in Tables I and II.

ANALYSIS

Alcohol Consumption and Liver Cirrhosis Death Rate

Three points are of major interest with regard to the relation between alcohol consumption and liver cirrhosis death rate: (a) How *close* is the correlation? (b) What is the seeming *form* of the relationship? (c) At what point of consumption might we expect liver cirrhosis deaths to be at a *minimum?*

The answer to the first question appears to be that the correlations are high and positive: the greater the consumption, the higher the death rate.

For Canada, the correlation between alcohol consumption and the crude liver cirrhosis death rate is .960, which "accounts for" (statistically) 92% of the variation. The correlation between alcohol consumption and the age-sex standardized death rate is lower but still considerable ($p = .910$) and it accounts for only a little less (83%) of the variance. The corresponding correlations for Ontario are very similar ($p = .969$ and .959, respectively).

The *fact* of a (statistical) relationship is hard to dispute. The *form* of that relationship is harder to establish. The question is essentially whether the basic relationship is linear—so that the death rate above a certain point is a simple multiple of the consumption rate, and deaths are at a minimum when consumption is at a minimum—or whether the relation is curvilinear, so that death rates tend to rise both above and below a certain consumption level. Statistical analysis favours (although it does not unequivocally establish) the second view. If we recall that the "consumption" we are speaking of is the "official" consumption (i.e. the consumption of alcohol from licit sources alone), the

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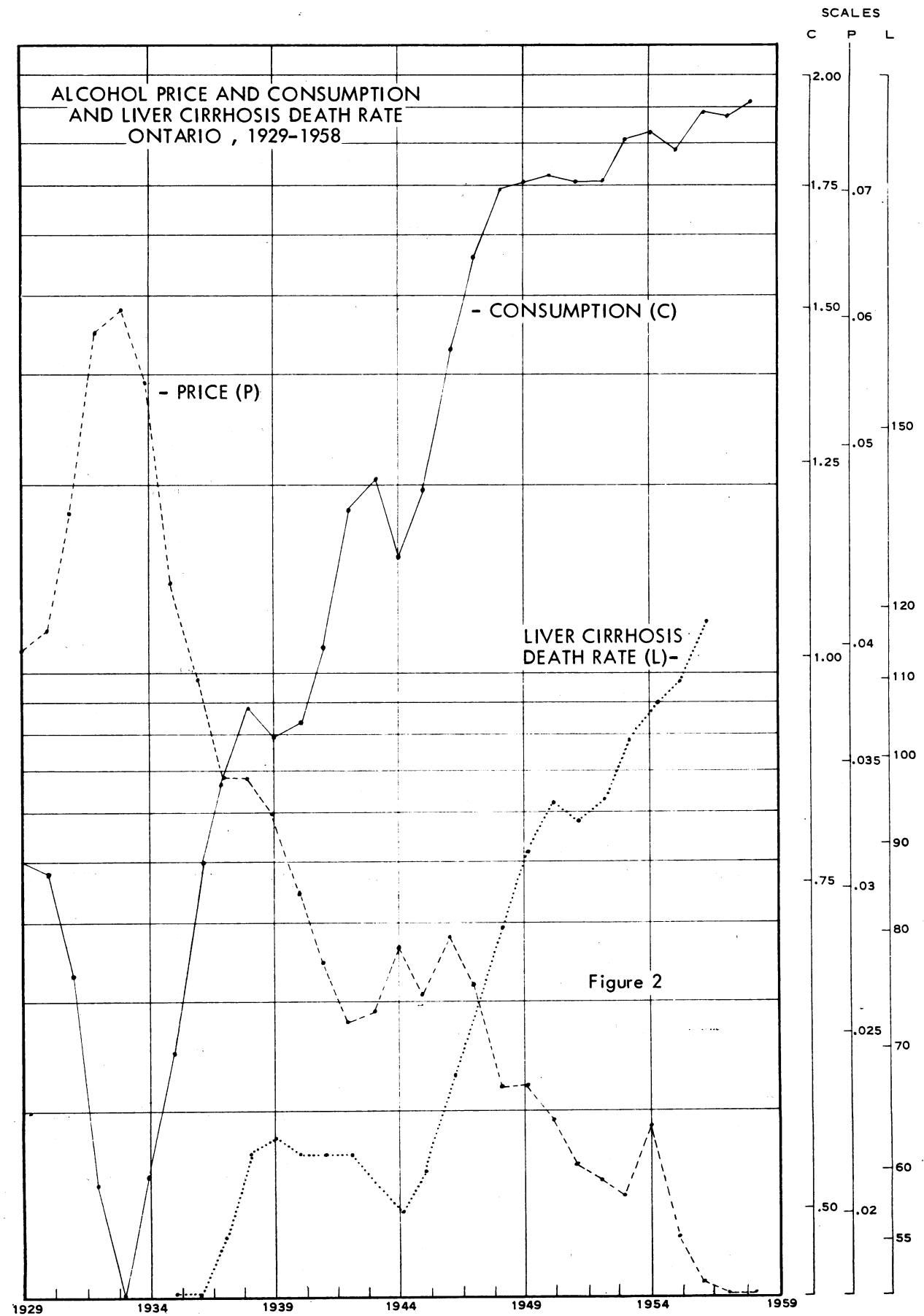
Fig. 2

TABLE I.—CANADA—AVERAGE STANDARD RELATIVE PRICE OF ALCOHOL, AVERAGE CONSUMPTION OF ALCOHOL AND AVERAGE ADULT DEATH RATE BY LIVER CIRRHOSIS*

Year	Price of alcohol†	Consumption of alcohol‡	Un-standardized liver cirrhosis death rate§	Standardized liver cirrhosis death rate‖
1926	.047	.62	—	—
1927	.049	.62	—	—
1928	.037	.77	—	—
1929	.041	.85	—	—
1930	.042	.87	—	—
1931	.046	.76	—	—
1932	.049	.65	—	—
1933	.065	.46	—	—
1934	.065	.46	—	—
1935	.052	.56	64.34	38.62
1936	.049	.63	65.17	38.75
1937	.046	.67	64.86	38.28
1938	.044	.74	68.38	40.05
1939	.044	.70	69.94	40.64
1940	.040	.74	67.08	38.68
1941	.037	.82	68.55	39.35
1942	.034	.91	72.60	41.44
1943	.035	.98	71.10	40.24
1944	.039	.82	69.13	38.98
1945	.037	.94	72.31	40.72
1946	.035	1.20	76.38	42.76
1947	.033	1.33	79.09	44.12
1948	.028	1.46	83.09	46.33
1949	.030	1.41	87.78	48.88
1950	.028	1.44	88.59	49.20
1951	.025	1.47	87.90	48.61
1952	.025	1.46	91.30	50.58
1953	.028	1.44	96.33	53.49
1954	.028	1.46	98.28	54.33
1955	.026	1.39	100.30	55.35
1956	.024	1.51	107.99	—

*The primary data upon which all rates shown in the table were based are to be found in *Statistics of Alcohol Use and Alcoholism in Canada, 1871-1956*. All liver cirrhosis death rates were corrected to allow for the effects of the Sixth Revision of the International Lists of Diseases and Causes of Death.
†Average price of an imperial gallon of absolute alcohol, shown as a fraction of average adult annual disposable personal income.
‡Average consumption per "adult" (person 15 years of age or older) in imperial gallons of absolute alcohol.
§Deaths attributed to liver cirrhosis, per 1,000,000 "adults" (person 20 years of age and over); centred two-year moving averages.
‖Expected deaths per standard million population.

TABLE II.—ONTARIO—AVERAGE STANDARD RELATIVE PRICE OF ALCOHOL, AVERAGE CONSUMPTION OF ALCOHOL AND AVERAGE ADULT DEATH RATE BY LIVER CIRRHOSIS*

Year	Price of alcohol†	Consumption of alcohol‡	Un-standardized liver cirrhosis death rate§	Standardized liver cirrhosis death rate‖
1929	.0400	.765	—	—
1930	.0409	.752	—	—
1931	.0471	.662	—	—
1932	.0589	.515	—	—
1933	.0605	.446	—	—
1934	.0555	.518	—	—
1935	.0434	.605	51.30	27.56
1936	.0386	.764	51.40	28.30
1937	.0342	.840	55.61	31.45
1938	.0342	.922	61.34	34.24
1939	.0327	.892	63.30	34.78
1940	.0298	.908	61.27	33.64
1941	.0273	.997	60.75	33.33
1942	.0254	1.175	61.51	33.46
1943	.0256	1.222	58.96	31.78
1944	.0278	1.107	57.18	30.88
1945	.0262	1.197	60.06	32.59
1946	.0280	1.435	66.70	36.07
1947	.0265	1.601	74.79	40.43
1948	.0234	1.737	80.99	43.96
1949	.0234	1.760	89.26	48.42
1950	.0225	1.766	94.63	51.49
1951	.0213	1.757	92.72	50.61
1952	.0209	1.775	94.99	51.99
1953	.0203	1.850	102.42	56.44
1954	.0222	1.876	106.69	58.84
1955	.0194	1.828	108.27	59.64
1956	.0183	1.917	115.49	—

*The primary data upon which all rates shown in this table were based are to be found in *Statistics of Alcohol Use and Alcoholism in Canada, 1871-1956*. All liver cirrhosis death rates were corrected to allow for the effects of the Sixth Revision of the International Lists of Diseases and Causes of Death.
†Average price of an imperial gallon of absolute alcohol, shown as a fraction of average adult annual disposable personal income.
‡Average consumption per "adult" (person 20 years of age or older) in imperial gallons of absolute alcohol.
§Deaths attributed to liver cirrhosis, per 1,000,000 "adults" (person 20 years of age and over); centred two-year moving averages.
‖Expected deaths per standard million population.

conclusion would run contrary neither to common sense nor to experience at other times and in other places, since it is credible that below a certain level of licit consumption enough illicit alcohol is made available to raise the true total consumption, and perhaps to increase the physical damage per unit consumed.

If the hypothesis of a curvilinear relation is accepted, then it appears that:

(a) For Canada: (i) The unstandardized liver cirrhosis death rate would be at a minimum (66 deaths per million adults per annum) when consumption fell to an average of .60 gallon of absolute alcohol per adult per annum. Put another way, we should expect a 38% reduction in 1956 death rates if consumption fell by 60%. (ii) The standardized liver cirrhosis death rate would be at a minimum (39 deaths per million standard population per annum) when consumption fell to an average of .65 gallon of absolute

alcohol per adult per annum. This would mean about a 30% reduction in deaths, given a 57% fall in alcohol consumption.

(b) For Ontario: (i) The unstandardized liver cirrhosis death rate would be at a minimum (56 deaths per million adults per annum) when consumption fell to an average of .89 gallon of absolute alcohol per adult per annum. This means 48% of present deaths, with a fall of 54% in current consumption. (ii) The standardized liver cirrhosis death rate would be at a minimum (31 deaths per million standard population per annum) when consumption fell to an average of .88 gallon of absolute alcohol per annum. This implies 52% of the deaths, given a 54% drop in consumption.

The foregoing relations may be presented synoptically in Table III.

Greater consistency than this between the findings for Ontario and Canada, or, within each, for the standardized and unstandardized rates is hardly to be expected, given the heterogeneity across

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"Canada" and the different meanings of the questions answered by the standardized and unstandardized rates, respectively. What seems clear enough is that death rates of both kinds in both political units are closely related to alcohol consumption, and that reductions by about a third to a half might be "expected" if alcohol consumption were cut to a third or a half or somewhere in between.

The prediction takes it for granted that other alcohol "supply" conditions remain the same. It is for this reason that only the period 1935-56 was chosen to correlate alcohol consumption and liver cirrhosis death rates; before that date, alcohol supply conditions were sufficiently different that the stricture "all other conditions being equal" did not apply.[6][b]

TABLE III.—CANADA AND ONTARIO— ALCOHOL CONSUMPTION AND LIVER CIRRHOSIS DEATH RATES, STANDARDIZED AND UNSTANDARDIZED

| Statistic | Liver cirrhosis death rate | | | |
| | Unstandardized | | Standardized | |
	Canada	Ontario	Canada	Ontario
Correlation between consumption and death rate	.96	.97	.91	.96
Percentage variance "accounted for"	92	94	83	92
Minimum death rate expected:				
(a) per million adults	66	56	39	31
(b) as percentage of 1955-6 death rate	62%	48%	70%	52%
Consumption point for minimum death rate:				
(a) in gallons absolute alcohol	.60	.89	.65	.88
(b) as percentage of 1956 consumption-rate	40%	46%	43%	46%

From 1929-34, as a matter of fact, liver cirrhosis deaths did *not* vary intimately with price and consumption (which did vary inversely for the whole period). If, however, a longer time period were chosen—say from the beginning of prohibition, circa 1915, to the present, close covariation between alcohol consumption and liver cirrhosis death rate would be visually obvious, and statistically reflected in high correlations.

Alcohol Price and Alcohol Consumption

It remains to show the dependency of alcohol consumption on alcohol price.

Since the same questions were asked of these data as were asked about the relation of death rates to alcohol consumption, with similar results, it seems idle to restate the findings in the text, and preferable to summarize them in Table IV.

Again, the data seem to assert that the relation between price and consumption is very close, and that as price falls consumption rises.

They seem to assert, further, that consumption would be at a minimum of about half a gallon of absolute alcohol per adult per annum, whether in Ontario or Canada as a whole, when the price of a gallon of absolute alcohol was about one-twentieth of an average adult income. While such a price would represent a 137.5% increase in Canada, and nearly a 200% increase in Ontario, it needs to be

TABLE IV.—CANADA AND ONTARIO—ALCOHOL PRICE AND ALCOHOL CONSUMPTION

| Statistic | Region | |
	Canada	Ontario
Correlation between price and consumption	−.99	−.96
Percentage variance "accounted for"	98%	92%
Minimum consumption expected:		
(a) in gallons absolute alcohol	.51	.49
(b) as percentage of 1956 consumption	34%	25%
Price at which minimum consumption expected:		
(a) as fraction of income*	.057	.053
(b) as percentage of 1956 price	238%	293%

*Price stated as a fraction of average adult annual disposable personal income.

recalled, to put the matter in perspective, that prices stood higher than this in Canada in 1933 and 1934, and in Ontario from 1932 to 1934. Consumption of less than half a gallon of absolute alcohol per adult also actually occurred in Canada in those two years, and in Ontario in 1933.

Alcohol Price and Cirrhosis Death Rates

If we omit consumption of alcohol as an "intervening variable"—even though common-sense may recommend it—and compute directly the regression between alcohol price and the death rates, we get results very similar to those already presented. Space permits no more than a statement of the correlations found—as in Table V below; and those interested may be referred for further detail to the basic documents.[8]

TABLE V.—CANADA AND ONTARIO—ALCOHOL PRICE AND LIVER CIRRHOSIS DEATH RATES—STANDARDIZED AND UNSTANDARDIZED CORRELATIONS

| Region | Statistic | Liver cirrhosis death rate correlated with alcohol price | |
		Unstandardized	Standardized
Canada	ρ	−.93	−.91
	ρ^2	(.86)	(.83)
Ontario	ρ	−.93	−.90
	ρ^2	(.86)	(.81)

These seem to be rather striking direct relations.

The chart already presented, which shows for Ontario, from 1929 to 1958, the movements of alcohol prices, alcohol consumption, and the unstandardized cirrhosis death-rate will, it is hoped, at least, avoid one too restricted interpretation of the correlations found: it is not the case simply that the price series has moved steadily down while the other series has moved steadily up. The covariation between all seems, on visual impression, as on statistical analysis, immediate, detailed and intimate.

DISCUSSION

It is one thing to establish the fact and nature of a relationship over a brief historical period, and quite another to assume a causal relationship,

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and moreover, a causal relationship that can be extrapolated to the future.

There is only one way to test such a pair of assumptions and that is by way of an experiment. If an attempt were made by a suitable government to change (in either direction) to a sufficient degree (say 20% to 30%) the already, in effect, administered price of alcohol for a sufficient period (say three years), it could be determined whether indeed licit alcohol consumption and, therewith, the rate of death by cirrhosis of the liver changed in the expected direction and to the expected degree.

If the price were changed in the upward direction, we might reasonably expect some saving of life as well as a gain in scientific knowledge, and the opening up of a possibility of public health gains on the basis of precisely tailored economic measures. It can be shown[8] also that, by a curiously happy relationship among the variables, the increased taxation that would secure the higher price, and lowered consumption and death rates, would add sufficient additional revenue to government (even in the face of the diminished consumption) to pay for a very substantial increase in public health programs, or indeed, in any other desired governmental program. In Ontario, for instance, a doubling of price, despite its effect in reducing consumption, might be expected approximately to double the government's net revenue from alcohol. (We might also, incidentally, learn something as to how illicit alcohol supply and methods of tension management other than alcohol consumption vary with the price of licit alcohol supply.) In any case, the anticipated effect on revenue might also be regarded as a matter for experimental verification. Certainly, we have a situation here where the anticipated costs do not by any means, *prima facie*, stand in the way of experiment in a public health improvement measure.

The ethical problems involved in raising the price of a commodity to all, so that disaster may be avoided for some, merit extended discussion at another time and place. In effect, this is not far different from what happens when hospitals are supported in part out of any general tax, particularly an excise or sales tax. In the present case, the measures discussed would, if effective, relieve the taxpayer and the economy of an already existing expense, at least if it were assumed that when mortality rates fell, morbidity rates and public expense for hospitalization would fall with them. Moreover, the increased tax revenue could be used to make available additional general services, so that drinkers would be taxed not primarily for problem drinkers but for common services for all.

SUMMARY

It appears that deaths from liver cirrhosis, though small in number, are increasing rapidly, and rise and fall with average alcohol consumption. It also appears that alcohol consumption rises and falls inversely with
alcohol price. It is sufficiently credible to justify a social experiment to determine whether an alcohol price increase would reduce liver cirrhosis mortality, while simultaneously furnishing a sizable increase in government revenue, and hence occasion an increase in government services or a reduction in other forms of taxation.

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THE PRACTICE OF GRIMNESS

The genocidal love affair between Americans and automobiles, which resembles nothing in the world so much as a rabbit hypnotized by a cobra, until recently gave no sign of yielding to admonitions or rational thought. Instead, the monster went its way, killing outright nearly 40,000 people a year and at leisure consuming the rest: indispensable, otiose, junky, improbable, it has served as an emotional vehicle for the ungrown and as the backbone of a near-civilization that may be remembered for its superhighways. They do it differently in Erewhon, where the driver of an automobile is quietly executed on the spot, a method that reasonably safeguards him from another accident. In time we too may develop a regard for human life.

An early sign appeared this summer in Pennsylvania, where all new drivers must have their physician's certification that they can see well enough and have the neuromuscular integrity to control an automobile, and that they are not dyspneic with heart failure, alcoholic, diabetic (uncontrolled), or subject to lapses of consciousness or certain other handicaps. If emotional unfitness is still too hard to assess, though the most lethal of all, the achievement in Pennsylvania is marvelous notwithstanding. It asserts for the first time that driving an automobile is not included in the Bill of Rights. The impression that it was might have been due to the predecessor vehicle, the horse and buggy, but never extended to, say, flying an airplane.

Now, and not for the first time, the physician is placed in a pivotal and often distressing role by the law of certification. It will become necessary to exhort these unfit drivers not to drive, and not to *want* to drive, for their own sake. There will be the usual run of highly exceptional circumstances, the routine "hardships" and special cases, in view of which the physician ought to be "more reasonable" and the inspired new law edentulous. Really to make the law work, physicians will have to be difficult and even grim. That was the experience in aviation: no one, in order to be a good fellow, signed a poor devil's life away, and the example can well be carried into driver certification. It will be worth any trouble.- Editorial: *Medical Tribune*, November 14, 1960.